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EFFECTS OF AVERAGING DATA DURING STIMULUS GENERALIZATION

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Rats were trained to press two keys consecutively for reinforcement. During stimulus one (slow clicker) a 6-sec time delay was required between the two responses. During stimulus eight (fast clicker) no time delay was required between the two responses. When tested with intermediate stimuli (intermediate click rates) the median time delays emitted by the animals were intermediate between their performances on the original training stimuli, resulting in typical generalization gradients. Closer examination of the data revealed that the median values were not representative of the behavior of the animals.

Stimulus generalization gradients are conventionally considered to have the form of a sloping gradient of response rates away from the reinforced stimulus (Guttman and Kalish, 1956). Some exceptions have been reported. Hearst (1962) obtained flat generalization gradients using an avoidance procedure prior to discrimination training but obtained a conventional sloping gradient of response rates after discrimination training, as did Sidman (1961). A second exception concerns the peak shift phenomenon following discrimination training (Hanson, 1959), where the sloping gradient is obtained but from a point displaced from the originally reinforced stimulus in a direction away from the unreinforced training stimulus. In general, a sloping gradient of response rates (and presumably response strength) is obtained when the trained subject is tested on stimuli removed from the training stimuli. This general result has survived a variety of testing procedures. Herrnstein and van Sommers (1962) for example, used five training stimuli and four test stimuli intermediate between the five training stimuli. They found that the response rates in the intermediate test stimuli were intermediate in relation to the rates in the adjacent training stimuli. Another variation in which two incompatible responses were available to the subject has been used. Honig and Day (1962) trained animals to respond to one key (iden-

tity key) when there was no difference in wavelength between two illuminated keys and to peck at a second key (difference key) when there was a difference of 40 millimicrons (mμ) in wavelengths. When tested at wavelength differences from 0 to 70 mμ there was a gradually decreasing amount of responding to the identity key as the difference increased, and an increasing amount of responding to the difference key. La Berge (1961) found a parallel result with human subjects using a two-response situation.

Some investigators, however, have raised questions about accepting the general shape of these generalization gradients. Blough (1963) showed that generalization test stimuli principally affected the long interresponse times, rather than the short ones after variable interval training. Cross and Lane (1963) using two topographically discontinuous (or continuous) responses found sharply sloping gradients of generalization relating response probability (of one response or the other) to stimulus intensity. Under the particular conditions of the present experiment, gradually sloping generalization gradients, presumably implying gradually changing strengths of behavior, were obtained. But they were found to be the result of averaging procedures, and actually unrepresentative of the behavior of the animals.

METHOD

Subjects

Two experimentally naive adult male albino rats served.

Apparatus

The Ss were housed and tested in a special purpose device called an elevator, described earlier (Migler and Brady, 1964). In this device the living cage becomes the testing cage when the testing panel is positioned in front of the living cage. The testing panel contained two response keys that could be illuminated from behind, pellet feeder, and speaker. Under program control this panel moved up from the home position at the bottom of the elevator, not facing any cage, to a cage in which a rat lived for a test session. Then it moved up to the second rat for another session and then home to the bottom of the elevator.

Conventional relay circuitry was used to program the contingencies, and the data were recorded on punched paper tape for later sorting and computation by a digital computer.

Procedures

Water was available at all times from a water bottle mounted on the cage. All nourishment was obtained from the 97 mg food pellets earned as reinforcements during the daily testing sessions. The number of reinforcements per session ranged from about 100 to 400. The use of the elevator and the punched tape recording system permitted seven day per week training. Daily sessions were 10 hr in duration for each rat with 14 hr of deprivation between sessions for each rat.

Preliminary Training. The rats were first food deprived for 24 hr, then over successive days, were magazined trained and trained under CRF conditions to press the illuminated response key on the left side of the cage (key B). Subsequently, over several sessions key A on the right hand side of the test panel was illuminated and key B was darkened. Pressing key B when darkened had no effect, pressing key A when illuminated extinguished the light on key A and illuminated key B. A press on key B at this time was reinforced with a pellet delivered into a trough between the keys near the floor, and the illumination was switched from key B back to key A. After the response A to response B sequence was established, illumination of key A after a key B response was discontinued, so that the cage was dark until the rat pressed key A which illuminated key B and started the run. When key B was pressed the cage was darkened and reinforce-

ment delivered. The purpose of this change was to provide for the later use of a limited hold procedure in which an excessive delay after response A would be indicated immediately by darkening of the cage.

Preliminary training continued with the introduction of a 1-sec minimum delay requirement between response A and response B. Only if the rat pressed key B at least 1-sec after it had pressed key A, was the food pellet delivered. A to B response times shorter than 1 sec were not reinforced. As training progressed this minimum was gradually increased to 6 sec. The limited hold was added at this point. Previously, the B light remained on indefinitely after the A response. Now a limit was imposed, so that 15 sec after the A response had occurred the cage was darkened, and the rat had to press key A again to set up a reinforcement on key B.

The next major step was to establish an auditory discrimination. The lighting arrangement on the keys was maintained as before and, in addition, when the trial (or run) was started by a press on key A a clicker was sounded until response B was made, or until the limited hold reset the trial after the 15-sec limit. The click frequency was either 2.5 per sec (stimulus one) or 45.8 per sec (stimulus eight) distributed randomly at 50% each. When stimulus eight was on, reinforcement on key B was immediately available, and when the A response turned on stimulus one the usual 6-sec minimum delay was in effect. Forty-five discrimination training sessions were necessary (including some sessions in which only stimulus one or stimulus eight was in effect for the entire session) to produce a clear separation of the behaviors in the two stimuli.

In the next and last step in preliminary training, reinforcement was delivered only after 50% of the appropriate A to B responses (10 sessions), and then after only about 33% (20 sessions). That is, during stimulus eight only about one-third of the sequences were reinforced. During stimulus one only one-third of those sequences over the 6-sec minimum were reinforced; the limited hold was in effect in both cases. This intermittent reinforcement was introduced to prevent rapid extinction during generalization testing, which was carried out in extinction.

Generalization Testing. On the generalization testing days, the procedure was modified

as follows: every tenth trial constituted a test; when the rat pressed key A, key B was illuminated as usual and a clicker sounded. The click rate of this test stimulus, however, was different from the click rate in the training stimuli. The other nine trials were regular training trials with either the 2.5 per sec clicker (stimulus one) or the 45.8 per sec clicker (stimulus eight) each occurring 50% of the time. A to B responding during the training stimuli was reinforced as usual on VR 3. The temporal requirements were maintained in stimuli one and eight. Six different test click rates (see Fig. 1) were investigated in an irregular order, but only one per session, and each was examined twice for a total of 12 test sessions.

RESULTS AND DISCUSSION

Figure 2 presents the performance of each rat on the last day of preliminary training. The time in seconds from response A to response B is presented on the abcissa, and the relative frequency (or percent of total) of each

Fig. 2. Performance of both rats on the training stimuli 1 (6-sec delay) and 8 (no delay). Performance in stimulus 1 is displaced upward for clarity.

A to B time is on the ordinate. The performance for the entire session during stimulus eight when no delay was required is shown on the bottom of each rat's set of curves with the peak shifted left toward the fast A to B times. The performance during stimulus one is merely displaced upward for clearer separation and for direct comparison of the two behaviors. The figure indicates that the discrimination was well established in both rats and that the behavior in each stimulus was appropriate to the temporal contingencies in that stimulus.

Figure 3 shows some of the results of the performance of the rats during the test stimuli. The median A to B time is given on the ordinate in this case, and the two curves for each rat indicate the two tests per stimulus. The figure presents a generalization gradient in which the median A to B time is roughly a continuous function of the click rate. During intermediate stimuli the median A to B times
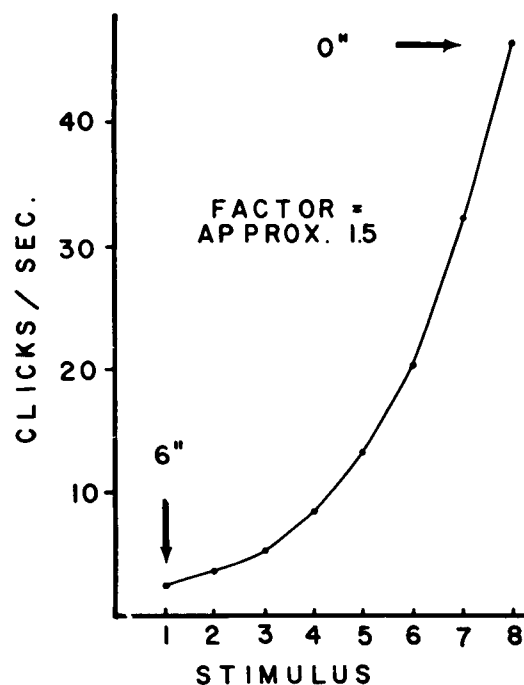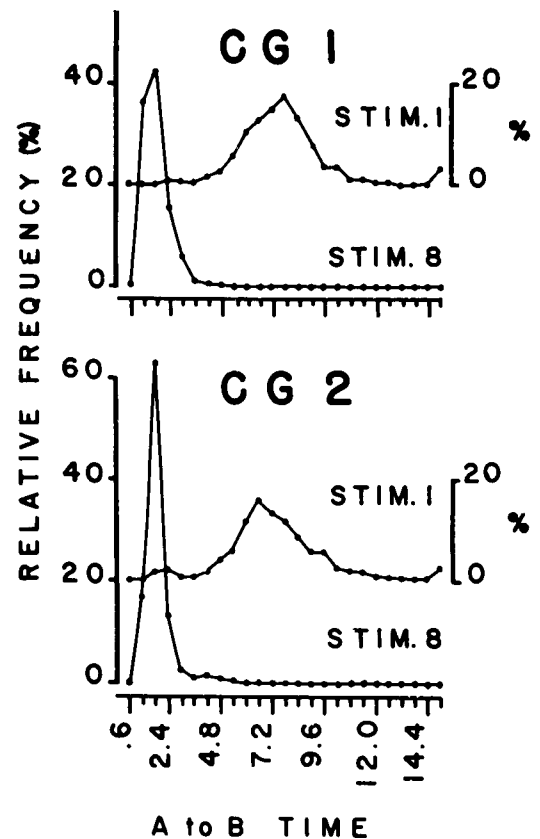

Fig. 1. Stimuli used during experiment. Training stimuli were stimulus 1 (2.5/sec) with a 6-sec minimum delay required between responses, and stimulus 8 (45.8/sec) with no delay required. Stimuli 2-7 were test stimuli.
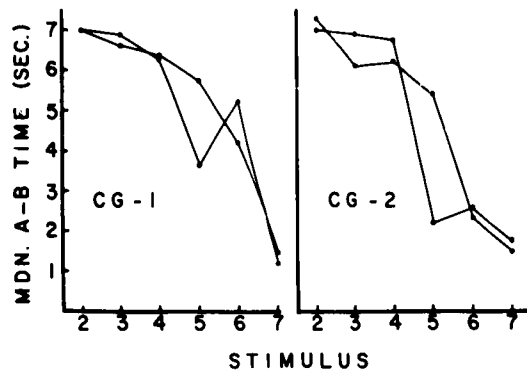
STIMULUS

Fig. 3. Median A to B time in the six test stimuli for both rats.

are intermediate between the performance in the training stimuli.

However, this method of treating the data presents a distorted description of the behavior of the animals. Figures 4 and 5 present the data in another way. Rather than averaging the data in each test stimulus by presenting the medians (or means, which presented the same picture), Fig. 4 and 5 present the relative

frequency distribution of A to B times in each test stimulus.

The abcissa represents the A to B times in seconds and the relative frequency of each A to B time is on the ordinate. The same magnitudes of the coordinates were used in all the curves in the figure. The lefthand column of curves shows the performance on the regular training stimuli, one and eight, during the 12 test sessions. The behavior in these stimuli were not affected in any systematic way by the testing procedure. The main effect of the experiment can be seen in the right-hand column of curves. Progressing from test stimulus two through test stimulus seven, the change in performance that takes place is the disappearance of behavior appropriate to stimulus one (slow A to B times) and the emergence of behavior appropriate to stimulus eight (fast A to B times), without the emergence of intermediate behaviors in the intermediate stimuli.

Clearly, the intermediate test stimuli do not generate intermediate behaviors, but only mixtures of behaviors, composed of fast A to B times and slow A to B times. The effect of the test stimuli was the control over the relative proportions of slow or fast A to B times in the mixture.

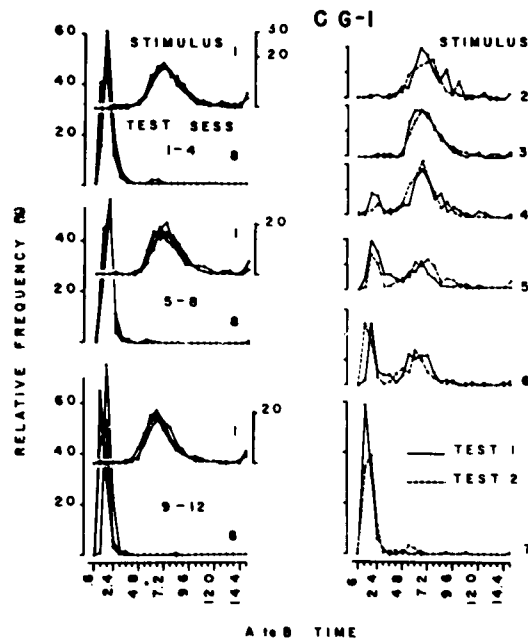Therefore, in this case at least, the sloping generalization gradients seen in Fig. 3 were

Fig. 4. Rat CG-1. Relative frequency distributions for performance during all 12 test sessions (two tests per test stimulus). The left-hand column of curves shows performance on the original training stimuli for the 12 sessions with the performance in stimulus 1 displaced upward. The right-hand column of figures shows the performance (and its replication) in each of the six test stimuli.
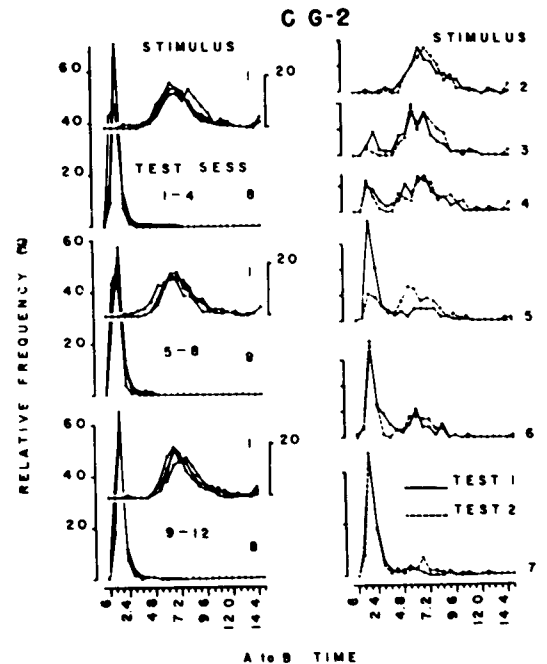

Fig. 5. Rat CG-2. See caption for Fig. 4.

entirely due to the effect of averaging different behaviors.

It is appropriate to inquire at this point whether the present results are related to other generalization testing procedures, e.g., where an animal is trained on a variable interval schedule of reinforcement in one stimulus and extinguished in a second stimulus and response rates during generalization testing are found to be a declining function of distance from the positive training stimulus (or from the shifted peak). A procedure which might illuminate the relevance of the present results to this data would require animals to respond to the left key (in a two-key chamber) on a VI of, say, 15 sec, in the presence of a low frequency click rate and on the right key on a VI of, say, 60 sec in the presence of a high frequency click rate. During intermediate test click rates, the results of the present experiment would predict that the animals would respond part of the time to the left key and part of the time to the right key. The average response rate for the two keys combined during a test stimulus would probably be intermediate between the rates on occurring during the training stimuli. However, the rates on the individual keys would not be intermediate VI rates but would be the rates characteristic of the 15-sec VI when the animal was working on the left key and the rate characteristic of the 60-sec VI when working on the right key. The overall intermediate rate would therefore be an artifact of averaging these different behav-

iors. Should such an outcome be approximately correct it would suggest that the sloping generalization gradients of response rates obtained with the single manipulandum procedure may be, in part, the result of inappropriate averaging procedures.

REFERENCES

Blough, D. S. Interresponse time as a function of continuous variables: A new method and some data. *J. exp. Anal. Behav.*, 1963, **6**, 237-246.

Cross, D. V. and Lane, H. L. On the discriminative control of concurrent responses: the relations among response frequency, latency, and topography in auditory generalization. *J. exp. Anal. Behav.*, 1962, **5**, 487-496.

Guttman, N. and Kalish, H. I. Discriminability and stimulus generalization. *J. exp. Psychol.*, 1956, **51**, 79-88.

Hanson, H. M. Effects of discrimination training on stimulus generalization. *J. exp. Psychol.*, 1959, **58**, 321-333.

Hearst, E. Concurrent generalization gradients for food-controlled and shock-controlled behavior. *J. exp. Anal. Behav.*, 1962, **5**, 19-31.

Herrnstein, R. J. and van Sommers, P. Method for sensory scaling with animals. *Science*, 1962, **135**, 40-41.

Honig, W. K. and Day, R. W. Discrimination and generalization on a dimension of stimulus difference. *Science*, 1962, **138**, 29-31.

LaBerge, D. Generalization gradients in a discrimination situation. *J. exp. Psychol.*, 1961, **62**, 88-94.

Migler, B. and Brady, J. V. Timing behavior and conditioned fear. *J. exp. Anal. Behav.*, 1964, **7**, 247-251.

Sidman, M. Stimulus generalization in an avoidance situation. *J. exp. Anal. Behav.*, 1961, **4**, 157-169.